FINAL REPORT

State: South Dakota Grant Number: T-49-R-1; Study Number 2459

Project Title

Preliminary investigation into migratory movements of bats in South Dakota

Period Covered

1 January 2011 through 30 June 2013

Investigators

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Justification and Need

The greatest challenge to the conservation of bats is limited knowledge of their biology and ecology (Racey and Entwistle 2003). Little is known about the timing and dynamics of bat migration in North America (Broders et al. 2003). A necessary step toward understanding the ecology or conservation status of bats is to develop a thorough understanding of their seasonal movement patterns. Conservation of migratory bats depends on obtaining more knowledge on their migratory phenology, stopover ecology, migratory flyways, and behavior (Holland and Wikelski 2009). Long-term acoustic monitoring using arrays of ultrasonic detectors will be required to provide accurate estimates of migratory behavior (Reynolds 2006, Council 2007a;b).

Gathering information on migratory bat movements has been previously limited by suitable methodology and the advanced technology required to address such needs (Cryan and Barclay 2009). The study of migration in birds is enabled by the ability to use mark-recapture/re-sight methods by placing leg-bands on birds. This methods has proved to be ineffective for migratory bats (Cryan and Barclay 2009). Many species of birds are also sufficiently large to safely mark and monitor individuals by radio or satellite telemetry (Fuller et al. 2005). Transmitters are still too large to humanely mark and collect long-term data from migrating bats (Holland and Wikelski 2009).

Study Area

Fifteen locations across the state of South Dakota were selected based upon perceived potential to provide habitat for migratory bats and to serve as potential migration corridors (Figure 1). These characteristics include riparian areas (Huron water treatment plant, Game, Fish and Parks Outdoor Campus, Bad River Ranches and Sioux San

Hospital), areas with lakes or reservoirs (Angustura and Shadehill reservoirs and Lake Hiddenwood State Park), forested mountainous areas (Elk Mountain and Battle Mountain fire towers and Custer National Forest), and areas that provide migratory stopover habitat for birds (LaCreek, Sand Lake, and Waubay National Wildlife Refuges).

Objectives

1. Describe (graphically) and detect (statistically) significant peaks in annual, monthly, and nightly bat activity (as measured by a bat activity index) at 16 selected bat migration stations located throughout South Dakota.
2. Determine if the 16 selected monitoring stations experience peaks in bat activity during spring and fall migration during each calendar year of the study (i.e. indicate bat migration corridors).
3. Determine if a correlation exists between environmental variables (time, temperature, wind speed, etc.) and a bat activity index at each of the 16 selected bat migration stations during spring and fall or throughout the calendar year
4. Measure annual and seasonal (spring and fall) bat species (or species group) richness at each of 16 selected bat migration stations.
5. Provide recommendations for a long-term bat migration monitoring program

Methods

In the spring of 2011 and 2012, SM2BAT acoustic detectors were deployed to run nightly at each site from spring through fall. A statewide network of 37 cooperators were contacted and recruited to assist with this project. Some cooperators helped to secure access to potential sites. Others were trained to monitor detectors, change batteries and collect data.

Depending on the year and the site, detectors ran from March through November. Each detector was programed to record high frequency sounds beginning at 30 minutes before sunset through sunrise for each location.

SonoBat software versions 2.9.6 and 3 was used for sound file analysis and bat call identification. Noise files were separated from bat call files (call files). Dependent upon programming, a detector will record in either WAC file format (a proprietary Wildlife Acoustics file format) or WAV file format. WAC files need to be converted to WAV before call analysis in SonoBat. If collected as WAC files, SonoBat adequately separates out the noise files when converting the data from WAC to wav. If it was recorded as WAV, it took longer to weed out the noise files.

Each call file was then identified to bat species or species-pairs if possible. The automatic bat species identification performed by SonoBat version 3 is not accurate for the Northern Great Plains region and each bat call file needs to be processed manually.

For some species, reference calls collected in South Dakota were used to assist with call identification.

Overlap in frequencies and call characteristics occur within recorded calls. Echolocation calls are variable and are dependent upon a variety of circumstances. Some factors that can affect bat echolocation calls include foraging activity, habitat type (open vs. cluttered), and social calls. Another factor that can impact the ability to identify calls is the quality of the recorded call. Distance of the bat from the recording unit and direction of the call in relation to the recording unit are two of the most important factors. Wind speed and direction can also affect the quality of the recording. Only calls displaying characteristics known to be associated with a specific species were used to identify to species. Not all recorded calls demonstrate such characteristic features. For those calls that were identified to species, we recognize that variation in call signatures does exist (Fenton 2003).

Two species whose calls can be difficult to distinguish are *Lasionycteris noctivagans* and *Eptesicus fuscus*. While these species are capable of making calls that are unique, they also make a similar call that can be problematic for analysis. At our current level of understanding, a weak or poorly recorded *Eptesicus fuscus* call often appears very similar to a typical *Lasionycteris noctivagans* call. In South Dakota, where such circumstances occur, the call is identified as being only narrowed down to the two species pair. In this region, these two species' call frequencies, when coupled with other call characteristics, are generally easily distinguishable from other species' calls.

If we were not able to identify a call file to species or species-pairs, it was classified to the genus *Myotis* or categorized as a bat with uncertain identification and plausible taxonomic classification was provided or the call was identified as a bat with unknown identification. If a species presence was uncertain at a given site and was not confirmed by other means, that species is suggested to be present at that site, but not included in species richness calculations. Each call file was also categorized according to the specificity to which the identification was made (species, species-pair, genus, uncertain or unknown), whether it was a migratory bat (yes, no or unknown) and if it was a *Myotis* species (yes, not or unknown). Migratory bat species include Eastern Red Bat (*Lasiurus borealis*), Hoary Bat (*Lasiurus cinereus*) and Silver-haired Bat (*Lasionycteris noctivagans*).

Each call file was assigned a year, season, month, day, and hour. In 2011, spring was defined as 20 March through 20 June, summer as 21 June through 22 September, fall as 23 September through 21 December, winter as 22 December through 19 March. Similarly, in 2012 spring was defined as 20 March through 19 June, summer as 20 June through 21 September, fall as 22 September through 20 December and winter as 21December through 19 March.

The data collection period at each site began with the recording of the first file (noise or bat call) and concluded with the last file being recorded. Sampling effort was measured by the number of nights a detector was operational at each site. Operational SM2BAT detectors record and document internal and external temperature every 5 minutes. Review of this information allowed us to determine nights during which a detector was operational. Loss of power, scheduling conflicts with the cooperator responsible for changing batteries in a detector, or an incorrectly programmed detector were the reasons for a deployed detector to not be operational. The number of nights a detector was not operating was determined using:

Data Collection Period = # nights operating + # nights not operating.

Each night began at 17:00 hours and extends through 16:59 hours the following day and was given the date of calendar day on which it started.

For each site the number of nights with and without recorded bat activity was determined. Knowing the number of nights operating and the number of nights in which bats were recorded, the number of nights with no recorded bat activity was determined using:

# of Nights Operating = # nights with bat activity + # nights without bat activity

The total number of call files served as an index to bat activity with each call file representing a bat passing by the detector and the detector recording the file. No estimates of bat abundance will be calculated as echolocation monitoring is properly used as an estimate or index of bat activity (Hayes 2000, Hayes et al. 2009).

Results

The collection of 1.35 terabytes of sound files greatly exceeded the original expectations and planning efforts for this project. Call analysis and data summary has been completed for four sites: Hiddenwood State Park, Bad River Ranch, Elk Mountain fire tower, and Shadehill reservoir. Work continues on call file analysis, data summary and data analysis from the remaining sites. The following addresses objectives 1, 2 and 4. Please refer to the “Ongoing Analysis” section for more information on objectives 3 and 5.

Lake Hiddenwood State Park (F-HIDDEN)

Initial detector deployment at this and 12 other sites in 2011 was affected by temperatures remaining below freezing until late April.

A detector was deployed at this site in 2011 and 2012 (Table 1). The level of effort as measured in operating detector nights varied substantially between years due to

cooperator availability in 2012 (Table 2). In 2011 and 2012, bats were recorded on 160 of the 239 (67%) nights during which the detector was operating. This percentage was similar between years.

A total of 31,016 bat calls were recorded at this site with over 30,000 of those calls recorded in 2011. Despite a limited sampling effort in 2012, this is the highest number of calls recorded at any one site in this study that has been summarized to date. The average number of bat calls recorded/night in 2011 (212) greatly exceeded that of 2012 (9.3). Seasonal bat activity peaked during the summer in both 2011 (30,029 calls) and 2012 (441 calls). Monthly activity peaked in July 2011 (18,418 calls) and in September 2012 (229 calls). In 2011, there were 2 large peaks in nightly activity, one occurring from 1-11 July where on peak nights approximately 600 to almost 1,000 bat calls were recorded (Figure 2). A second and stronger nightly peak in 2011 occurred from 25 July through 14 August with peak of 3,594 bat calls recorded on 5 August. Nightly activity peaks in 2012 were much shorter and less pronounced with only 3 nightly peaks occurring on 10 May (44 calls), 7 September (73 calls) and 27 September (73 calls; Figure 3). Unfortunately, during the time period in which there was peak bat activity in 2011, the detector was not operating in 2012 (July and all of August).

Almost 90% of the calls recorded at the Hiddenwood site we identified to species. Eleven bat species were documented at Lake Hiddenwood State Park (Table 3). Red Bats were the most frequently recorded species at this site in both years. In 2012, both the Red Bat and Silver-haired bat, accounted for 29% and 26% of the calls recorded, respectively. The abundance of Red Bats at this site may account for the high identification rate. The call signature of this species is easy to distinguish from the other probable bat species in the area. The known county ranges (Higgins et al. 2000) of five bat species were expanded including Western Long-eared Myotis (*Myotis evotis*) Western Small-footed Bat (*Myotis ciliolabrum*),Fringed Myotis (*Myotis thysanodes),* Long-legged Myotis (*Myotis volans*) and Townsend's Big-eared Bat (*Corynorhinus townsendii*).

The number of migratory bat calls peaked in July (15,977 calls) and August (9,942 calls) 2011 at the Hiddenwood site suggesting a migratory stopover or corridor at this location. In 2011, the number of calls recorded peaked at 03:00 hours an indication of migratory flight. This 03:00 hour peak was also evident in 2012, although not as strong.

Species richness peaked at the Lake Hiddenwood site during the summer (11 species; Table 4). Monthly species richness was highest in July (10). Eight species were present in the spring. Hoary Bat was the first and only species recorded in March. Silver-haired (*Lasionycteris noctivagans*) and Eastern Red Bat (*Lasiurus borealis)* arrived in April and May, respectively. Species richness peaked in July with 10 species recorded. On 12 September, 3 call files of Townsend's Big-eared Bat (*Corynorhinus townsendii)* were

recorded. Fall species richness was low (3) and was comprised of the three migratory bat species.

Turner's Bad River Ranch (H-TURNER)

A detector was deployed at this site in both 2011 and 2012 for a total of 312 nights in the data collection period (Table 1). Permission to access the site was not obtained until later during the field season in 2011 and the number of nights operating was limited (74 nights; Table 2) due to late detector deployment (26 July). In addition, the detector was not operational for 25 of the 99 nights in the data collection period due, in part, to an initial error in detector programming. The length of the data collection period (213 nights) was much longer and the percentage of nights operating (96%) improved at the Bad River Ranch site in 2012.

Over both years, bats were recorded on 56% of the nights (Table 2). A total of 14,995 bat calls were recorded at the Bad River Ranch site with an average of 53.7 bat calls per night. In 2011, the detector ran for a short period (74 nights) and recorded 11, 259 call files (average of 152.1 call/night) an index to increased bat activity at this site. Average call files/night in 2012 was 18.2. Flooding on the Missouri River in 2011 may have shifted the movement of bats further west to this site along the Bad River. Despite the difference in the total number and rate at which calls were recorded between years, most calls were recorded during the summer months in both 2011(11,180) and 2012 (3,519). The month of September had the highest bat activity in 2011 (5,800 calls). Bat activity peaked in August 2012, with 2,462 calls. In 2011 there were three nights where bat activity peaked: 10 August (1,798 bat calls), 8 September (1, 608 bat calls), and 10 September (1,733 bat calls; Figure 4). Similarly in 2012, the most calls recorded on one night (534) occurred on 10 August (Figure 5). However, despite temporal similarities in peak activity, the magnitude of these peaks was much lower in 2012 than those documented in 2011. The next highest nightly peak in activity in 2012 included 325 bat calls recorded on 20 August.

Eighty percent of the calls recorded at this site were identified to species. Ten percent were classified as unidentified bat. Ten bat species were recorded at Bad River Ranch (Table 5). The most common call recorded at this site was that of the Eastern Red Bat (*Lasiurus borealis;* 66.6% of calls). This was true in both 2011(75.2%) and 2012 (43.8%). As at the Lake Hiddenwood site, the high percentage of calls identified to species may be accounted for by the unique call signature of this species. Western Small-footed bat (*Myotis ciliolabrum;* 32.2%) and Silver-haired Bat (*Lasionycteris noctivagans*; 2.0%) were far less commonly found, but more frequent that any of the other 7 species recorded. This project expanded the known range (Higgins et al. 2000) of Long-legged Myotis (*Myotis volans)*, Fringed Myotis (*Myotis thysanodes*), and Tricolored Bat (*Perimyotis subflavus*) in South Dakota.

74.7% of the total number of bat calls recorded at Bad River Ranch were from migratory bats. Of those, Eastern Red Bat (*Lasiurus borealis)* was the most common (96.2%). Peak call activity at this site for migratory bat species mirrors peak monthly call activity for all bats combined suggesting that this site is used during migratory bat movements. As with the Lake Hiddenwood site, calls peaked during the 0300 hour in both years indicating migratory movements. Migratory bats are known to fly throughout the night.

Seasonal species richness peaked at Bad River Ranch in the summer during the month of August (10; Table 6). Five species were recorded in the spring with the Western Small-footed Bat (*Myotis ciliolabrum*) being the earliest species recorded at Bad River Ranch. *Lasionycteris noctivagans* arrived in April followed by Hoary Bat (*Lasiurus cinereus)* in May *and Eastern Red Bat (Lasiurus borealis)* in June*.* All three migratory species were present at this site in October.

Shadehill Reservoir (N-SHADEHILL)

This site was operational only in 2012. It was selected as a site to fill in a geographical data collection gap in the western portion of the state and is located along the Grand River. The data collection period at this site began on 16 April and ran until 22 October for a data collection period of 189 nights (Table 1). The detector at this site was operational for 113 nights (60% of the data collection period) and bats were present on 95 (84%) of those nights (Table 2). Shadehill Reservoir had a higher percentage of nights in which bats were present compared to other sites evaluated to date. 12,988 bat calls were recorded with an average of 115 calls per night.

Bat activity was highest (8,900 calls) during the summer at Shadehill Reservoir despite a large number of summer nights in which the detector was not running. A considerable number of bat calls (4,002) were recorded during the spring at this site which may be an indication of migratory activity. The number of calls at Shadehill Reservoir peaked during July (4,191). Similar numbers of calls were recorded in both August (3,335) and May (3,135). Peaks in nightly activity at Shadehill Reservoir occurred on 27 July (472) and 27 August (429) and 11 May (362; Figure 6). The timing of monthly and nightly peaks in activity may suggest a single spring pulse in migratory bat activity and two increases in activity in the fall. The difference in the magnitude of seasonal and nightly peaks at this site is much less than documented at Bad River Ranch or Lake Hiddenwood.

Only 2,736 bat calls (21%) were identified to species at this site (Table 2). A similar number of calls were either not identified (2,633) or identified to the genus Myotis (2,897). This may have been due to the large number of Myotis species present at the site. Ability to assign bat calls to specific taxonomic categories was lower than at other sites.

Ten bat species were confirmed to be present by acoustic detectors at the Shadehill Reservoir (Table 7). Townsend's Big-eared Bat (*Corynorhinus townsendii*) may be present at this site. No particular species dominated the bat community at Shadehill Reservoir. Calls identified to the species pair Little Brown Bat/Long-legged Myotis were most frequently recorded at this site (3,633 bat calls; 28%). A similar number of calls from unknown species of the Myotis genus (2,674 calls; 20.6%) and unidentified bat calls (2,633 calls; 20%) were recorded. The data collected at this site expands the known county range (Higgins et al. 2000) of Western Small-footed (*Myotis ciliolabrum*) and Fringed Myotis (*Myotis thysanodes*). It also suggests a change in the known county range of Townsend's Big-eared Bat (*Corynorhinus townsendii)* in South Dakota.

Only 1,052 calls (8.1%) were recorded from migratory bat species at Shadehill Reservoir. Of those, the Eastern Red Bat (*Lasiurus borealis*) was most frequently recorded (484 calls; 46.0%). Calls of Hoary Bats (*Lasiurus cinereus*) were the least frequently recorded of the migratory bats (197 calls; 18.7%). Migratory bat activity was highest during July (638 calls) and August (355 calls). The next largest monthly peak occurred in May with (157 calls). A low percentage of migratory bat calls recorded at this site and reduced early morning activity (03:00 hours), suggest that this sight may not be primary migratory route. However, peaks in monthly activity for all bats and for migratory bats are similar, suggesting that these species are present, especially during May, July and August.

Seasonal species richness peaked at 10 in both spring (May) and summer (August). Nine of the 10 bat species documented at the Shadehill Reservoir site were present in April. Presence or absence of the Hoary Bat (*Lasiurus cinereus)* and Long-legged Myotis (*Myotis volans)* accounted for the slight fluctuation in generally consistent species richness throughout spring and summer. Eastern Red Bat (*Lasiurus borealis)* and Silver-haired bat (*Lasionycteris noctivagans*) were first detected in April. Hoary bats (*Lasiurus cinereus)* were not detected until May and were last detected during August. Silver-haired Bats (*Lasionycteris noctivagans*) were the last migratory species detected in October.

Elk *Mountain Fire Tower (I-ELKMNT)*

This site was only operational in 2011 due to a limited amount of data that were collected (Table 1). The 155 day data collection period ran from 15 May through 17 October. The detector at this site was operational on 69 of the 155 nights with bats being detected on 41 (59%) of those operational nights. A total of 1,168 bat calls were recorded with an average of 17 calls per night. This is the lowest nightly average of the four sites summarized to date.

Bat activity was highest during the summer (1,086 calls) at Elk Mountain with the months of July (499) and August (558) having the highest number of calls. Note that many of the nonoperation nights occurred during May and June. The largest documented peak in nightly activity at Elk Mountain occurred on 26 July (325 calls). Other peak activity nights included 5 August (150 bat calls), 25 August (101 bat calls), and 22 August (94 bat calls; Figure 7).

Slightly over half of the calls recorded (55%) were identified to species (639 calls). Twenty-seven percent of the calls (313) recorded were identified as a bat with no further identification possible. Seven species were documented at Elk Mountain using acoustic recorders (Table 9). Silver-haired bat calls (*Lasionycteris noctivagans*; 466) were most frequently recorded comprising almost 40% all calls.

Forty-seven percent of all calls recorded were from migratory bats. Of those 553 migratory bat calls, 466 calls (84%) were from Silver-haired Bats (*Lasionycteris noctivagans*). Migratory bat activity was highest during the summer months of July (255) and August (257). Hourly activity at this site peaked during the 00:00 hour.

Seasonal species richness peaked during the summer during August (7; Table 10.) Silver-haired Bat (*Lasionycteris noctivagans*) and Hoary Bat (*Lasiurus cinereus*) were the first species detected in May and were the only two species detected during the spring. There were no bat calls recorded during the summer in June due to a nonoperational detector. Eastern Red Bat (*Lasiurus borealis)* and Silver-haired Bat (*Lasionycteris noctivagans*) were the 2 migratory species detected during the fall in September. No bat calls were recorded in October; the detector at this site was operational for only 5 nights in October.

When call analysis and data summary are complete for the remaining 11 sites, comparisons of bat activity indices and species richness among sites and among months at each site will be made using the Chi-Square goodness-of-fit test.

Ongoing Analysis

Due to incomplete call analysis and the overwhelming amount of data that need to be managed, correlation analysis has not been complete for any of the sites (objective 3). Weather data have been collected from four automated weather stations through South Dakota's State Office of Climatology's website (http://climate.sdstate.edu) using the nearest station to each of the four study sites. Weather data management includes the development of a key variable to link the bat and weather data sets. Data are currently being merged together using Program R. Due to the large amounts of bat and weather data available and the hourly temporal scale at which analysis is possible, we are currently considering what is the best temporal scale (hourly, weekly, bi-weekly, monthly) at which look for correlations. Correlations between bat activity index at each

site and temperature and wind speed will be calculated using Pearson's product moment correlation coefficient and associated t-test. We are also reevaluating the use of comparing bat activity according to seasons as currently defined. Distinctive and consistent changes in weather patterns, especially temperature that indicate a seasonal shift (not a change in season based on the calendar) may be a better indicator of migratory bat movements.

Call analysis, data summary and analysis have not yet been completed making the following long-term monitoring recommendations preliminary (objective 5). However a few recommendations have begun to develop. Each site summarized to date has had a number of nights during which the detector was nonoperational. For long-term monitoring I would recommend investing in solar panel to ensure consistent sampling effort across sites and to ensure appropriate temporal coverage at each site. Coordinators were a great part of this project in that it helped to build relationships among wildlife professionals and the general public as well as increasing awareness about bats in South Dakota.

The importance of multiple year monitoring could not be stressed enough. Variation at one site in one given year indicates that short term inventories or monitoring efforts would not provide adequate information on bat activity at certain sites.

Some sites such as Lake Hiddenwood State Park and Turner's Bad River Ranch have obvious seasonal pulses of migratory bat activity. These sites are those that should receive priority monitoring efforts.

Amount Obligated: $ (*SDGFP will complete this.*)

Actual cost to date: $ (*SDGFP will complete this.*)

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Table 1. Data collection periods for bat migration monitoring stations in South Dakota, 2011-2012.

		Data Collection		
		Start	Stop	Total
F-HIDDEN	2011	5-May	3-Nov	183
	2012	26-Mar	18-Oct	207
	Total			390
H-TURNER	2011	26-Jul	2-Nov	99
	2012	26-Mar	25-Oct	213
	Total			312
I-ELKMNT	2011	15-May	17-Oct	155
N-SHADEHILL	2012	16-Apr	22-Oct	189

Table 2. Summary of sampling effort and nights bats were recorded at four bat migration monitoring stations in South Dakota, 2011-2012.

	# Nights							Bat calls	
	operating	bats present		no bats		not operating		total #	avg/night
F-HIDDEN	142	85	60%	57	40%	41	22%	30,111	212.0
	97	75	77%	22	23%	110	53%	905	9.3
	239	160	67%	79	33%	151	39%	31,016	129.8
H-TURNER	74	42	57%	32	43%	25	34%	11,259	152.1
	205	114	56%	91	44%	8	4%	3,736	18.2
	279	156	56%	123	44%	33	12%	14,995	53.7
I-ELKMNT	69	41	59%	28	41%	86	55%	1,168	17
N-SHADEHILL	113	95	84%	18	16%	76	40%	12,988	115

Table 3. Species and frequency of bat calls recorded at Lake Hiddenwood State Park, South Dakota.

Common Name	Scientific Name	2011		2012		Total	
Townsend's Big-eared Bat	*Corynorhinus townsendii*	3	0%	-	-	3	0%
Big Brown Bat	*Eptesicus fuscus*	27	0%	22	2%	49	0%
Red Bat	*Lasiurus borealis*	25,491	85%	258	29%	25,749	83%
Hoary Bat	*Lasiurus cinereus*	245	1%	55	6%	300	1%
Silver-haired Bat	*Lasionycteris noctivagans*	725	2%	234	26%	959	3%
Western Small-footed Bat	*Myotis ciliolabrum*	218	1%	11	1%	229	1%
Western Long-eared Myotis	*Myotis evotis*	1	0%	-	-	1	0%
Little Brown Bat	*Myotis lucifugus*	46	0%	21	2%	67	0%
Northern Long-eared Bat	*Myotis septentrionalis*	56	0%	12	1%	68	0%
Fringed Myotis	*Myotis thysanodes*	8	0%	1	0%	9	0%
Long-legged Myotis	*Myotis volans*	20	0%	3	0%	23	0%
Myotis species	*Myotis spp.*	148	0%	71	8%	219	1%
Big Brown Bat/Silver-haired Bat	see above	1	0%	-	-	1	0%
Western Small-footed Bat/Northern Long-eared Bat	see above	1	0%	-	-	1	0%
Western Long-eared Myotis/Fringed Myotis	see above	271	1%	87	10%	259	1%
Myotis species/Western Long-earred Myotis	see above	1	0%	-	-	1	0%
Myotis species	*Myotis spp.*	199	1%	13	1%	212	1%
Bat, uncertain identification		351	1%	30	3%	381	1%
Bat, identification unknown		2,299	8%	87	10%	2,386	8%
		30,111		905		31,016	

Table 4. Seasonal and monthly phenology of bat species recorded at Lake Hiddenwood State Park, South Dakota, 2011-2012

		Spring					Summer					Fall		
Common Name	**Scientific Name**	Mar	Apr	May	Jun		Jun	Jul	Aug	Sep		Sep	Oct	
Townsend's Big-eared Bat	*Corynorhinus townsendii*									X				
Big Brown Bat	*Eptesicus fuscus*			X	X		X	X	X					
Red Bat*	*Lasiurus borealis*			X	X		X	X	X	X		X	X	
Hoary Bat*	*Lasiurus cinereus*	X	X		X		X	X	X	X		X	X	
Silver-haired Bat*	*Lasionycteris noctivagans*		X	X	X		X	X	X	X		X	X	
Western Small-footed Bat	*Myotis ciliolabrum*		X	X	X		X	X	X	X				
Western Long-eared Myotis	*Myotis evotis*							X						
Little Brown Bat	*Myotis lucifugus*		X	X	X		X	X	X					
Northern Long-eared Bat	*Myotis septentrionalis*			X			X	X	X	X				
Fringed Myotis	*Myotis thysanodes*							X	X					
Long-legged Myotis	*Myotis volans*		X	X	X			X	X					
		1	5	7	7	**8**	7	10	9	6	**11**	3	3	**3**

Table 5. Species and frequency of bat calls recorded at Bad River Ranch, South Dakota.

Common Name	Scientific Name	2011		2012		Total	
Big Brown Bat	*Eptesicus fuscus*	94	0.8%	139	3.2%	233	1.4%
Eastern Red Bat	*Lasiurus borealis*	8,843	75.2%	1,928	43.8%	10,771	66.6%
Hoary Bat	*Lasiurus cinereus*	35	0.3%	75	1.7%	110	0.7%
Silver-haired Bat	*Lasionycteris noctivagans*	101	0.9%	216	4.9%	317	2.0%
Western Small-footed Bat	*Myotis ciliolabrum*	352	3.0%	158	3.6%	510	3.2%
Little Brown Bat	*Myotis lucifugus*	7	0.1%	1	0.0%	8	0.0%
Northern Long-eared Bat	*Myotis septentrionalis*	23	0.2%	24	0.5%	47	0.3%
Fringed Myotis	*Myotis thysanodes*	9	0.1%	-	-	9	0.1%
Long-legged Myotis	*Myotis volans*	61	0.5%	1	0.0%	62	0.4%
Tricolored Bat	*Perimyotis subflavus*	2	0.0%	26	0.6%	28	0.2%
Big Brown Bat/Silver-haired Bat	*see above*	103	0.9%	407	9.3%	510	3.2%
Little Brown Bat/Long-legged Myotis		146	1.2%	52	1.2%	198	1.2%
Myotis species	*Myotis spp.*	225	1.9%	123	2.8%	348	2.2%
Bat, uncertain identification		255	2.2%	203	4.6%	458	2.8%
Bat, identification unknown		1,003	8.5%	383	8.7%	1,386	8.6%
		11,763		4,398		16,161	

Table 6. Seasonal and monthly phenology of bat species recorded at Bad River Ranch, South Dakota, 2011-2012

		Spring					Summer					Fall		
Common Name	**Scientific Name**	Mar	Apr	May	Jun		Jun	Jul	Aug	Sep		Sept	Oct	
Big Brown Bat	*Eptesicus fuscus*			X	X		X	X	X	X		X	X	
Red Bat	*Lasiurus borealis*				X		X	X	X	X		X	X	
Hoary Bat	*Lasiurus cinereus*			X	X		X	X	X	X		X	X	
Silver-haired Bat	*Lasionycteris noctivagans*		X	X	X		X	X	X	X		X	X	
Western Small-footed Bat	*Myotis ciliolabrum*	X		X	X		X	X	X	X		X		
Little Brown Bat	*Myotis lucifugus*							X	X					
Northern Long-eared Bat	*Myotis septentrionalis*							X	X	X				
Fringed Myotis	*Myotis thysanodes*								X	X				
Long-legged Myotis	*Myotis volans*							X	X	X				
Tricolored Bat	*Perimyotis subflavus*							X	X			X	X	
		1	1	4	5	**5**	5	9	10	8	**10**	6	5	**6**

Table 7. Species and frequency of bat calls recorded at Shadehill Reservoir, South Dakota, 2012.

Common Name	**Scientific Name**	**Total**	**%**
Big Brown Bat	*Eptesicus fuscus*	239	1.8%
Red Bat	*Lasiurus borealis*	484	3.7%
Hoary Bat	*Lasiurus cinereus*	197	1.5%
Silver-haired Bat	*Lasionycteris noctivagans*	371	2.9%
Western Small-footed Bat	*Myotis ciliolabrum*	394	3.0%
Long-eared Myotis	*Myotis evotis*	366	2.8%
Little Brown Bat	*Myotis lucifugus*	127	1.0%
Northern Long-eared Bat	*Myotis septentrionalis*	435	3.3%
Fringed Myotis	*Myotis thysanodes*	112	0.9%
Long-legged Myotis	*Myotis volans*	11	0.1%
Big Brown Bat/Silver-haired Bat	see above	867	6.7%
Little Brown Bat/Long-legged Myotis	see above	3,633	28.0%
Fringed Myotis/Townsend's Big-earred bat	see above/*Corynorhinus townsendii*	1	0.0%
Myotis species	*Myotis spp.*	2,674	20.6%
Bat, uncertain identification		444	3.4%
Bat, identification unknown		2,633	20.3%
		12,988	

Table 8. Seasonal and monthly phenology of bat species recorded at Shadehill Reservoir, South Dakota, 2012.

		Spring					**Summer**					**Fall**		
Common Name	**Scientific Name**	Mar	Apr	May	Jun		Jun	Jul	Aug	Sep		Sept	Oct	
Big Brown Bat	*Eptesicus fuscus*	-	X	X	X		X	X	X	X			X	
Red Bat*	*Lasiurus borealis*	-	X	X	X		X	X	X	X		X		
Hoary Bat*	*Lasiurus cinereus*	-		X			X	X	X					
Silver-haired Bat*	*Lasionycteris noctivagans*	-	X	X	X		X	X	X	X		X	X	
Western Small-footed Bat	*Myotis ciliolabrum*	-	X	X	X		X	X	X	X		X		
Western Long-eared Myotis	*Myotis evotis*	-	X	X	X		X	X	X	X		X		
Little Brown Bat	*Myotis lucifugus*	-	X	X	X		X	X	X	X		X		
Northern Long-eared Bat	*Myotis septentrionalis*	-	X	X	X		X	X	X	X		X		
Fringed Myotis	*Myotis thysanodes*	-	X	X	X		X	X	X	X				
Long-legged Myotis	*Myotis volans*	-	X	X					X	X				
		0	9	10	8	**10**	9	9	10	9	**10**	6	2	**7**

Table 9. Species and frequency of bat calls recorded at Elk Mountain Fire Tower, South Dakota, 2011.

Common Name	**Scientific Name**	**# Calls**	**%**
Big Brown Bat	*Eptesicus fuscus*	64	5.5%
Red Bat	*Lasiurus borealis*	8	0.7%
Hoary Bat	*Lasiurus cinereus*	79	6.8%
Silver-haired Bat	*Lasionycteris noctivagans*	466	39.9%
Western Small-footed Bat	*Myotis ciliolabrum*	18	1.5%
Little Brown Bat	*Myotis lucifugus*	1	0.1%
Fringed Myotis	*Myotis thysanodes*	3	0.3%
Big Brown Bat/Silver-haired Bat	see above	178	15.2%
Little Brown Bat/Long-legged Myotis	see above/*Myotis volans*	2	0.2%
Myotis species	*Myotis spp.*	9	0.8%
Bat, uncertain identification		27	2.3%
Bat, identification unknown		313	26.8%
		1,168	

Table 10. Seasonal and monthly phenology of bat species recorded at Elk Mountain Fire Tower, South Dakota, 2011.

Common Name	Scientific Name	Spring					Summer					Fall		
		Mar	Apr	May	Jun		Jun	Jul	Aug	Sep		Sept	Oct	
Big Brown Bat	*Eptesicus fuscus*	-	-					X	X	X		X		
Red Bat*	*Lasiurus borealis*	-	-						X			X		
Hoary Bat*	*Lasiurus cinereus*	-	-	X				X	X					
Silver-haired Bat*	*Lasionycteris noctivagans*	-	-	X	X			X	X	X		X		
Western Small-footed Bat	*Myotis ciliolabrum*	-	-					X	X			X		
Western Long-eared Myotis	*Myotis lucifugus*	-	-						X					
Little Brown Bat	*Myotis thysanodes*	-	-						X					
		0	0	2	1	**2**	0	4	7	2	**7**	4	0	**4**

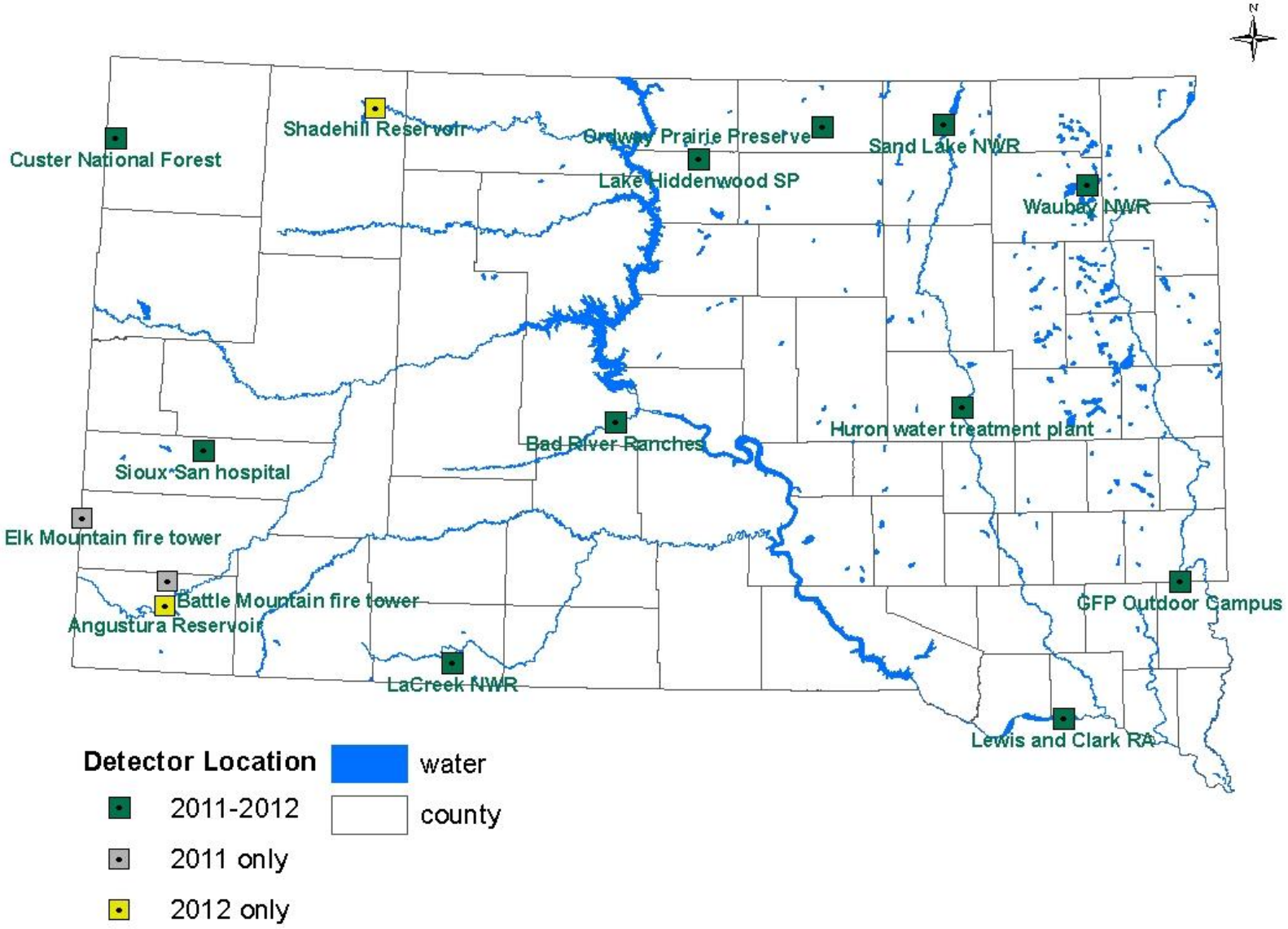

Figure 1. Location of bat migration monitoring stations in South Dakota, 2011-2012.

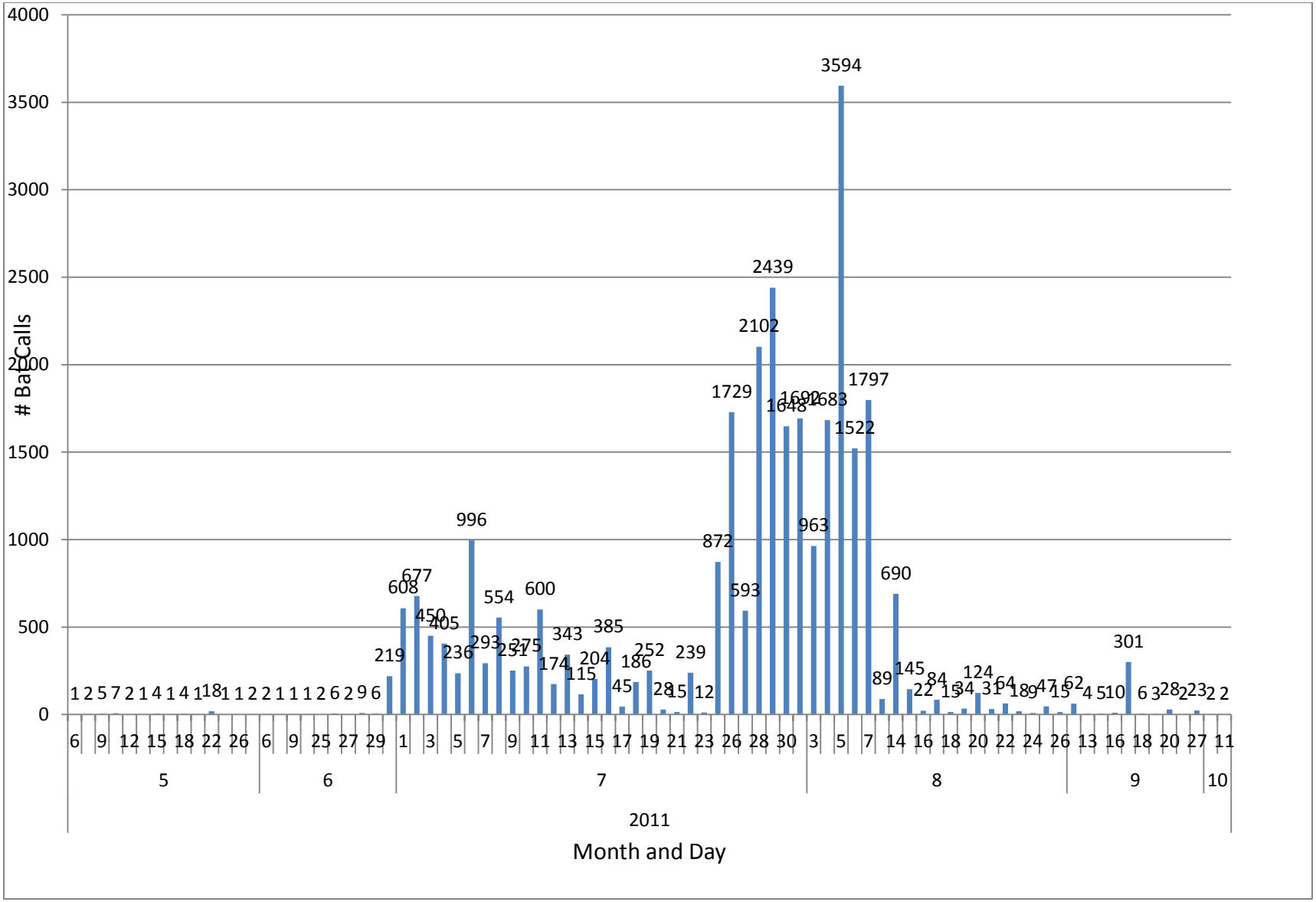

Figure 2. Nightly bat activity as indicated by recorded calls at Lake Hiddenwood State Park, 2011.

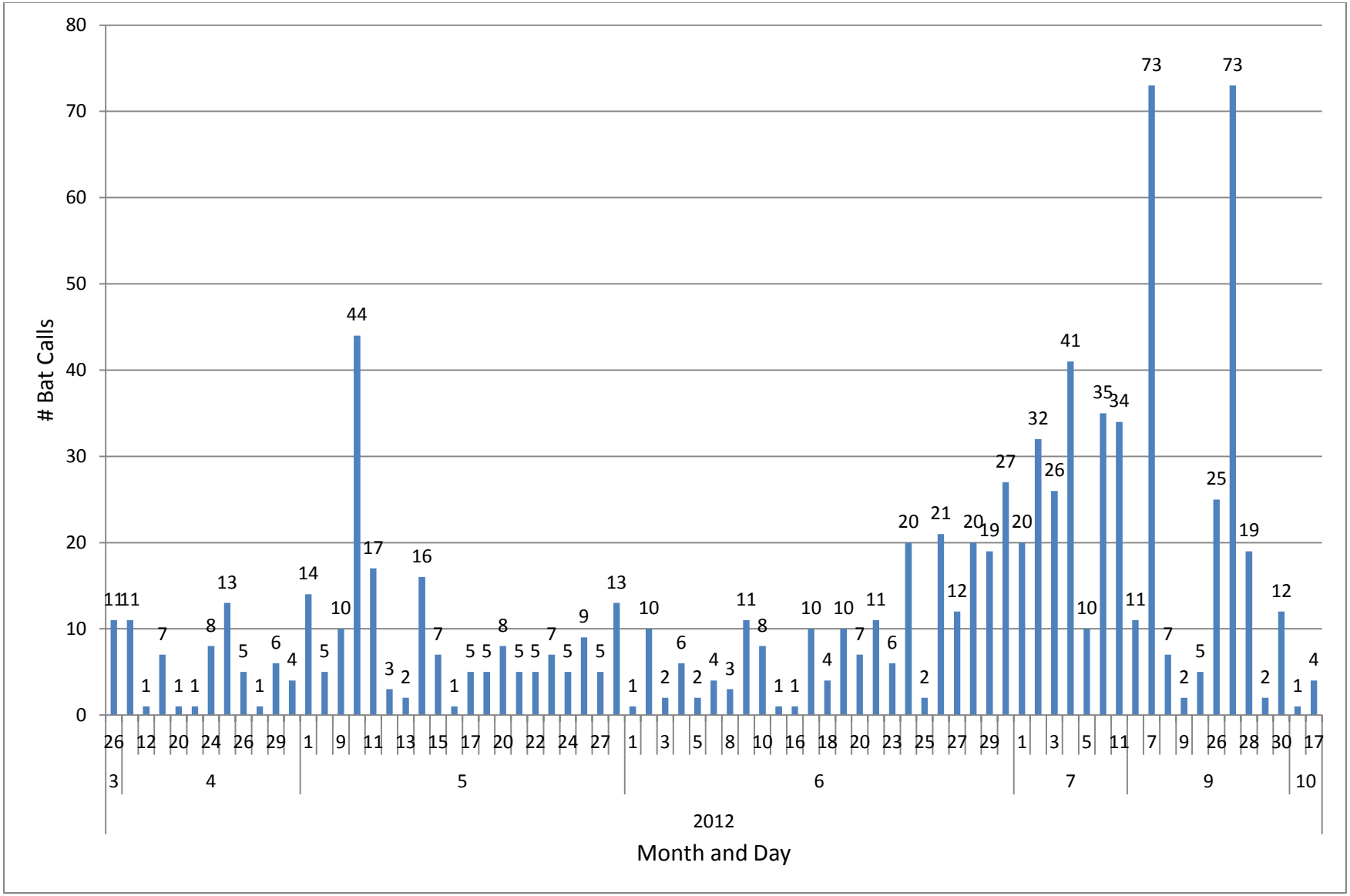

Figure 3. Nightly bat activity as indicated by recorded calls at Lake Hiddenwood State Park, 2012.

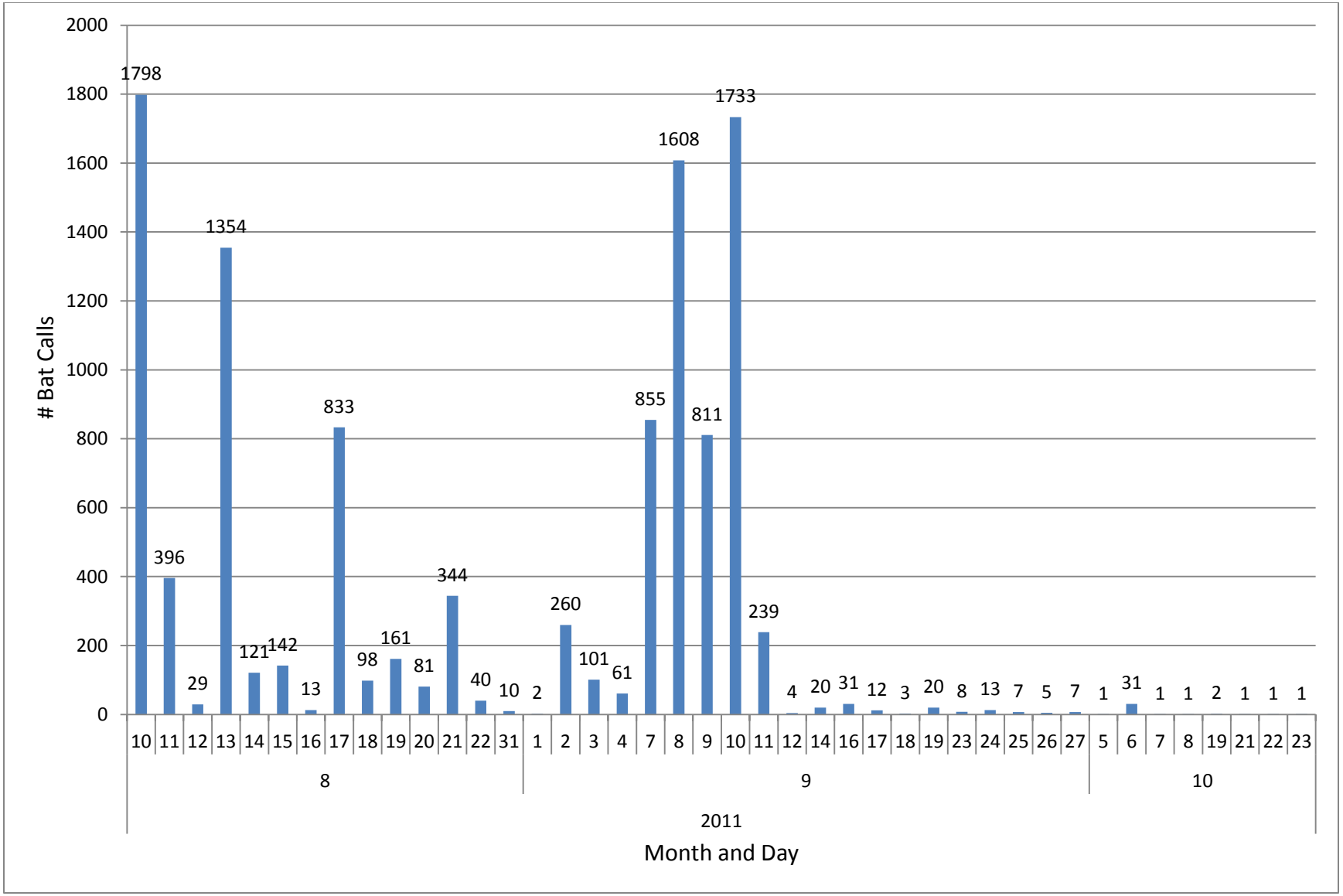

Figure 4. Nightly bat activity as indicated by recorded calls at Turner's Bad River Ranch, 2011.

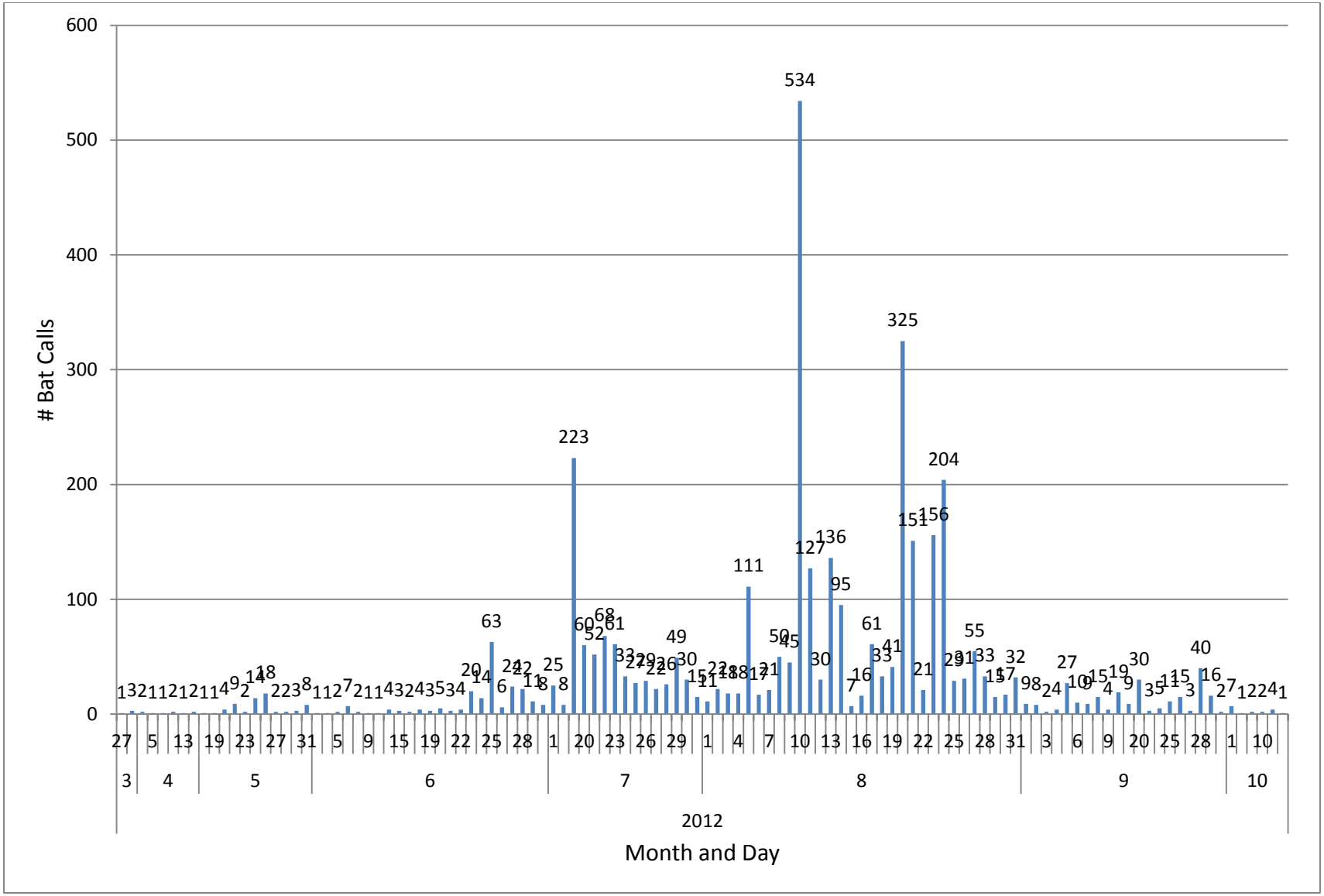

Figure 5. Nightly bat activity as indicated by recorded calls at Turner's Bad River Ranch, 2012.

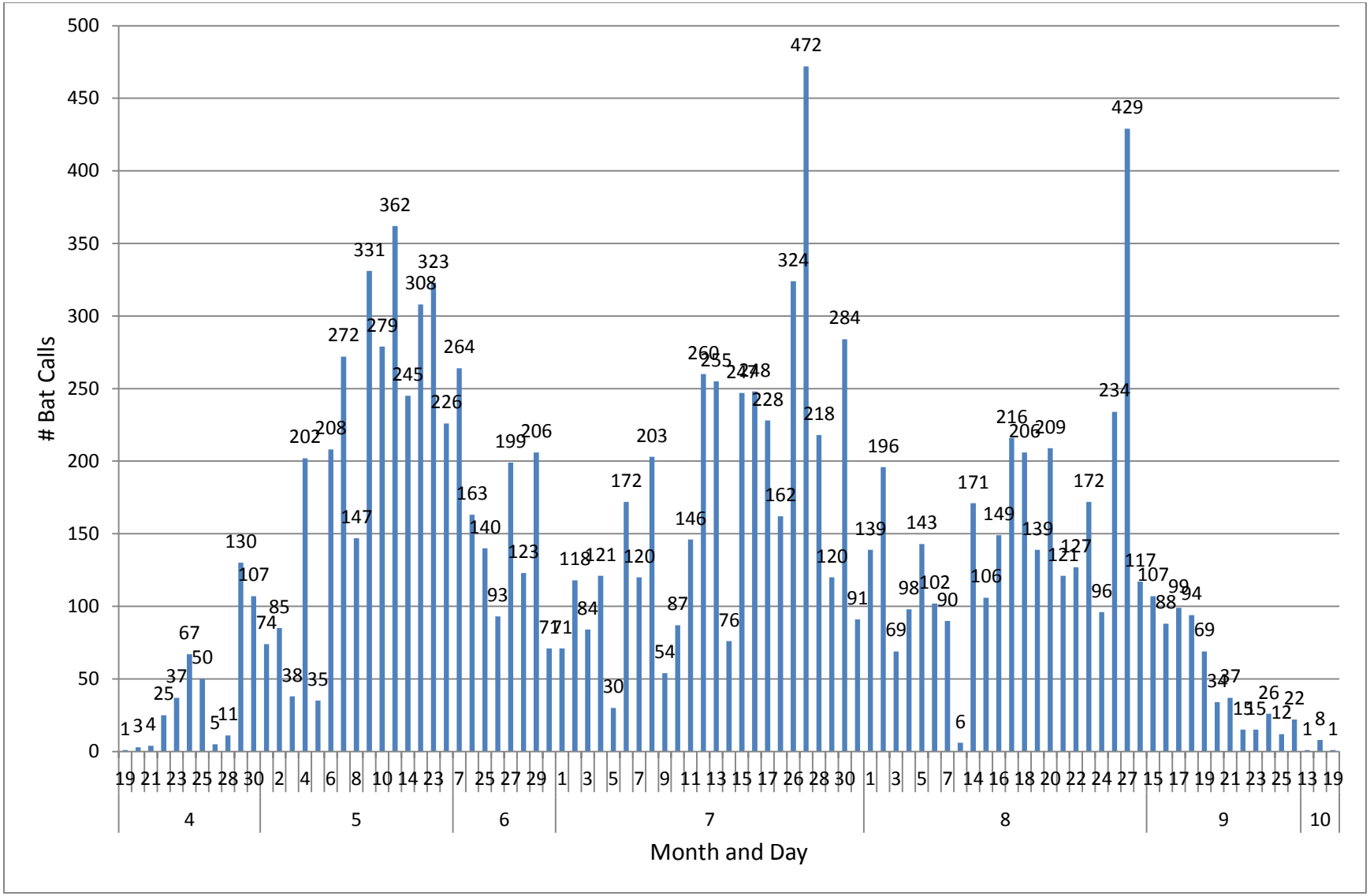

Figure 6. Nightly bat activity as indicated by recorded calls at Shadehill Reservoir, 2012.

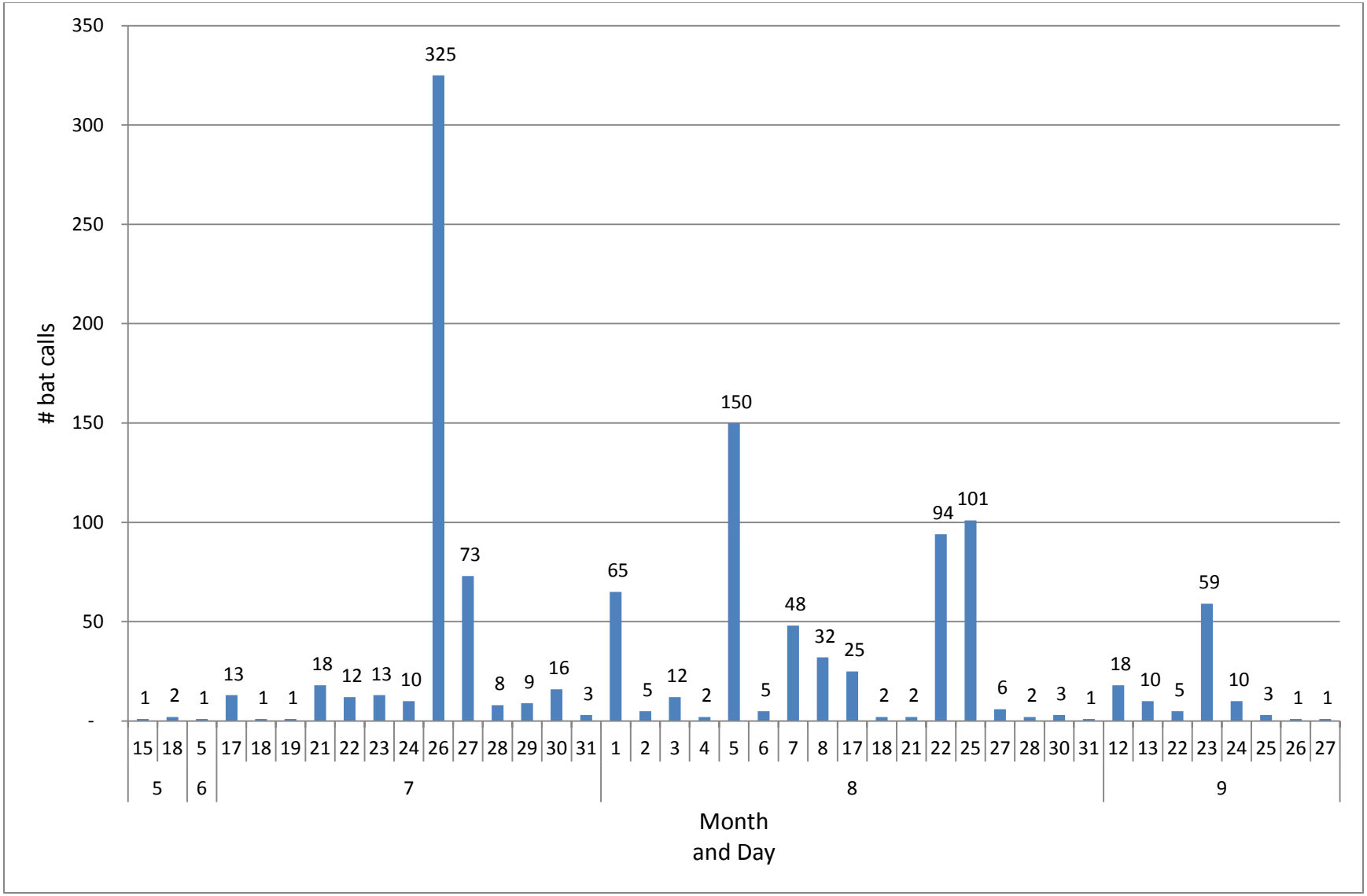

Figure 7. Nightly bat activity as indicated by recorded calls at Elk Mountain Fire Tower, 2011.